Tropical maize response to nitrogen and starter fertilizer under strip and conventional tillage systems in southern Alabama

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Abstract

Tropical maize (*Zea mays* L.) is a promising new crop for the southeastern US, but optimum management practices have not been established for this alternative crop. Field studies were initiated in 1990 to evaluate its response to N and starter fertilizer under conventional and reduced tillage systems double cropped following wheat (*Triticum aestivum* L.). The experiment was conducted on a Dothan sandy loam (fine–loamy, silicious, thermic Plinthic Paleudults) in Southern Alabama. Treatments included conventional (chisel plowing (25 cm depth), disking, and in-row subsoiling) and strip (in-row subsoiling) tillage systems; four N rates (0, 56, 112 and 168 kg ha^{-1}); and five starter fertilizer combinations: (1) no starter; (2) 22.4 kg N ha^{-1}; (3) 22.4 kg P ha^{-1}; (4) 22.4 kg N and 22.4 kg P ha^{-1}; (5) 22.4 kg N, 22.4 kg P and 11.2 kg S ha^{-1}. The depth of subsoiling was 40 cm for both tillage systems. Tropical maize hybrids' Pioneer® Brand X304C (1990) and Pioneer® Brand 3072 (1991 and 1992) were utilized in the study. Maize silage yields (averaged over 1990 and 1991) under conventional tillage were 14% lower than with strip tillage, while grain yields in 1991 were 30% lower. Differences among tillage systems were not significant in 1992 except for the 0 and 168 kg N ha^{-1} rates where conventional tillage produced slightly higher yields as compared to strip tillage. Silage and grain yields increased with N rate with the largest response to N occurring in 1991 under strip tillage. For silage yields averaged over both tillage systems in 1990 and silage and grain yields in 1991 and 1992 under strip tillage there was a quadratic response to N rate. Silage and grain yields peaked at approximately 112 kg N ha^{-1}. Under conventional tillage in 1991 and 1992, the response of silage and grain to N rate was linear. The best starter for silage was the N and P (NP) treatment. For grain, N alone gave the same yield as the NP starter in 1991, with the greatest response occurring under conventional

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tillage. In 1992, the NP treatment was the best starter for grain. This study demonstrated that double cropped tropical maize is a promising alternative crop for warm temperate/subtropical regions. High silage yields and reasonable grain yields can be obtained using conservation tillage systems and the addition of N in combination with a starter fertilizer containing N and P. Published by Elsevier Science B.V.

1. Introduction

Maize hybrids developed for tropical and subtropical climates are an important source of grain and silage. For example, in Latin America countries, there is an estimated 5.1 million ha of tropical maize (Cortez, 1991). Interest in tropically adapted maize hybrids has increased in the southeastern United States during the past few years. It has been estimated that over 20,000 ha were grown in 1991, primarily for silage (Wright et al., 1991). The estimated potential for tropical maize in the Southern US is about 75,000–100,000 ha. Due to its late planting date, tropical maize can serve as an alternative crop in double-cropping systems using soybean (*Glycine max* (L.) Merr.), grain sorghum (*Sorghum bicolor* (L.) Moench) and temperate maize (*Zea mays* L.) (Teare et al., 1991a; Wright et al., 1990a,b). The potential to produce a late season grain crop, in addition to high silage yields, makes tropical maize an attractive alternative crop for warm temperate/subtropical regions.

Several studies have suggested that tropical hybrids usually do not respond to the addition of high rates of N and generally yield less grain than temperate hybrids (Muleba et al., 1983; Yamaguchi, 1974; Lang et al., 1989). Other research is contradictory (Gallaher et al., 1992). On sandy soils in North Florida, optimum grain and dry matter yields were obtained when 101 kg N ha^{-1} were applied at planting in combination with an additional 34–67 kg N ha^{-1} as a sidedress (Lang et al., 1989). Lord and Gallaher (1991) reported that irrigated tropical maize on a deep sandy soil was not affected by N rates greater than 67 kg ha^{-1} when applied in split applications (half at planting and half when the plants were 40-cm tall). However, Gallaher et al. (1992) reported that silage and grain yields of a tropical maize hybrid increased with N rates up to 202 kg ha^{-1} when grown in a no-tillage system on a sandy soil in North Florida.

There is no published data concerning tropical maize response to starter fertilizer in the southeastern US. In reduced tillage systems, corn growth is generally poor during the early part of the growing season and lower yields are sometimes obtained (Austin, 1972). Poor early-season growth in reduced tillage systems has been associated with several factors including cool soil temperatures (Unger, 1978; Warrington and Kanemasu, 1983), especially if large amounts of mulch are left on the soil surface (Blevins and Cook, 1970; Phillips, 1974). Slower than normal plant growth with lower soil temperatures has been attributed to a combination of poor root development (Beauchamp and Lathwell, 1967; Knoll et al., 1964), slower organic matter mineralization rates (Bauer and Black, 1981; Blevins et al., 1983; Dick, 1983; Doran, 1980) and low nutrient

availability (Ketcheson, 1968; Reyes et al., 1977). Starter fertilizer, or the placement of small amounts of soluble fertilizer in close proximity of the seed at planting, can increase root development and plant growth especially in cool soils. With the addition of starter fertilizer, even on high fertility soils (i.e., high residual P), increased early season plant growth and increased yields have been reported for temperate maize (Reeves et al., 1986; Touchton and Karim, 1986; Touchton, 1988; Wright, 1989) grown in southern USA. In the Southeast, most of the increased yields have been attributed to the N in the starter, however, in some situations optimum yields were obtained by including both N and P. Since tropical maize is planted later than temperate maize when soils are relatively warmer, tropical maize may not respond to starter fertilizer. Evaluating tropical maize response to starter fertilizer would be beneficial to the southern USA and other regions where tropical maize is produced on sandy soils.

Double-cropping tropical maize with wheat (*Triticum aestivum* L.) using conservation tillage would be a desirable system. The system would be environmentally sound and potentially increase the sustainability of an existing farm by providing an extra source of silage/grain as well as providing more ground cover throughout the year. However, little data has been collected regarding the N requirements of tropical maize when grown as a double-crop, under no-tillage or conventional tillage systems (Reeves et al., 1991). There is also a need to assess starter fertilizer needs for tropical maize when grown as a double-crop, under conservation and conventional tillage. The objectives of this study were to determine the optimum N rate for double-cropped tropical maize under conventional and strip tillage systems and to evaluate the response of tropical maize to starter fertilizer in these systems. Information generated from this study should be beneficial to the southern USA and other temperate/subtropical regions where tropical maize is grown on sandy soils.

2. Methods

A 3-yr field study was initiated in 1990 on a Dothan sandy loam soil in southern Alabama, USA. The experimental site was located on the Alabama Agricultural Experiment Station Wiregrass Substation (31°24′N, 85°15′W). The climate at the substation is classified as subtropical with no dry season and a mean annual rainfall of 127 cm, and a mean annual temperature of 19°C (Shaw, 1992). Soil at this location has a 0.04–0.1 m thick tillage or traffic pan at 0.20–0.35 m below the surface at the transition of the Ap to Bt horizons. The Dothan soil was developed from thick beds of unconsolidated, medium to fine textured marine sediments of the Coastal Plain and has a sandy loam texture in the surface Ap/BE horizon and a sandy clay loam texture in the Bt horizons. Soil pH (Hue and Evans, 1986) in the Ap horizon was approximately 6.3. Potassium had a 'medium' soil test rating based on the Mehlich I or dilute-double acid extractant (Mehlich, 1953) and the Auburn University Soil Testing Laboratory (Adams et al., 1994). Potassium was applied preplant at rates of 111 and 67 kg ha^{-1} in 1991 and 1992, respectively. Phosphorus had a 'high' soil test rating (Adams et al., 1994) and no additional P fertilizer was applied.

Treatments consisted of two tillage systems, five starter treatments, and four rates of N. The experiment had a split–split plot design with the two tillage systems as whole plots, starter fertilizer treatments as split plots and N rates as split–split plots. Each plot was 9.12 m in length and consisted of eight rows with a 91.4 cm spacing. Tillage treatments consisted of strip and conventional tillage. Conventional tillage consisted of chisel ploughing to a depth of 25 cm and disking followed by in-row subsoiling at planting. Strip tillage consisted of in-row subsoiling and planting into wheat stubble. This resulted in a 20- to 30-cm wide tilled zone. Depth of subsoiling for both tillage systems was approximately 40 cm. Subsoiling was necessary since (as noted previously) the Dothan soil develops a hard pan at the bottom of the plow layer. The five starter treatments were: (1) no starter; (2) 22.4 kg N ha^{-1}; (3) 22.4 kg P ha^{-1}; (4) 22.4 kg N + 22.4 kg P ha^{-1}; and (5) 22.4 kg N + 22.4 kg P + 11.2 kg S ha^{-1}. Rates and combinations of N, P and S were based on results of previous studies evaluating temperate maize response to starter fertilizer (Reeves et al., 1986; Touchton and Karim, 1986; Touchton, 1988; Wright, 1989). Commercial and reagent grade fluid fertilizer solutions were used for the starter fertilizer treatments. For the N alone starter treatments, a urea and ammonium nitrate solution (UAN) containing 28% N was used. Reagent grade phosphoric acid was used for the P alone (P) starter treatment. For the N and P (NP) starter treatment, a combination of ammonium polyphosphate (11–37–0; N–P_2O_5–K_2O) and UAN was used. For the N, P and S (NPS) starter treatment, a mixture of ammonium thiosulfate (11–0–0–27; N–P_2O_5–K_2O–S), ammonium polyphosphate and UAN were used. Starter treatments were applied at planting using a constant volume of 23 l ha^{-1} in an approximate 5 × 5 cm placement. Nitrogen rates (0, 56, 112, and 168 kg ha^{-1}) as ammonium nitrate were applied as a sidedress approximately 4 weeks after planting. The average height of the plants at sidedress was 0.3 m.

Wheat (*T. aestivum* L.), variety Coker 9766, was planted in the entire experimental area each fall. The seeding rate was 67 kg ha^{-1}. After the wheat matured in late spring, the test area was prepared according to tillage system.

Tropical maize hybrid Pioneer X304C was planted on 1 June 1990 and tropical maize hybrid Pioneer 3072 was planted on 4 June 1991 and 13 June 1992. Plant population for all 3 yr of the study was approximately 49,400 plants ha^{-1}. Grain was harvested from the two middle rows of all plots on 10 October 1991 and 14 October 1992. Grain yields were not determined in 1990 due to severe fall armyworm (*Spodoptera frugiperda* J.E. Smith) pressure. Grain moisture was corrected to 155 g kg^{-1}.

Maize silage yields were determined by cutting a total of 3 m of row plot^{-1}. Silage was harvested on 28 August, 5 September, and 9 September in 1990, 1991, and 1992, respectively. The whole plants were weighed and subsamples collected to determine dry matter content. In 1990, subsamples for dry matter determination consisted of 5 plants plot^{-1}. During 1991 and 1992, 8 plants plot^{-1} were chopped with a commercial chipper–shredder and subsamples of approximately 450 g plot^{-1} were collected. Subsamples were dried at 60°C and weighed. Silage yields were corrected to a dry matter content of 350 g kg^{-1}.

Maize ear leaves were collected for elemental analysis in 1991 and 1992. A total of 10 ear leaves plot^{-1} were collected at early silk, dried at 60°C and ground. Subsamples of the leaves were digested for nutrient analysis using a dry ashing procedure (Hue and

Evans, 1986). Phosphorus, Ca, K, Mg, Mn, Cu and Zn in the resulting digests were measured by inductively coupled argon plasma spectrophotometry (ICP, Thermo Jarell-Ash, Franklin, MA). Nitrogen was determined using a LECO C–H–N analyzer (LECO, St. Joseph, MI).

In 1991 and 1992, forage quality of the harvested silage was determined. Quality measurements included crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF). Forage quality was determined using near infrared reflectance spectroscopy (NIR). Dried forage samples were ground twice, packed into cells, and scanned 32 times with a NIR Spectrophotometer (NIRSystems, Silver Springs, MD) at a spectra range of 1100–2500 nm to determine CP, ADF, and NDF (Marten et al., 1989). Calibrations were made using ISI software (Infrasoft International, State College, PA, Marten et al., 1989).

Silage quality, nutrient analysis and yield data were analyzed statistically using SAS procedures (SAS Institute, 1985). Means were separated with Fisher's protected LSD at the 0.05 level of probability. For significant effects, treatment means were used to develop regression equations to describe the response to N rate.

3. Results and discussion

3.1. Ear leaf analysis

Ear leaves were not collected in 1990 since few maize ears developed due to severe fall armyworm damage and drought conditions (Table 1). In 1991 and 1992, there were no treatment effects on the levels of Ca, K, Mg, Mn, Zn or Cu in the corn ear leaf tissue (data not shown). For both years, P concentration in ear leaves increased with increasing rates of N regardless of tillage or starter treatment (Fig. 1). The sufficiency range for P in maize ear leaves collected at early silk from temperate maize has been reported to be 2.5–4.5 g kg^{-1} (Plank, 1989). The observed P concentrations were either below or on the lower end of this critical range for temperate maize. Phosphorus levels in tropical maize ear leaves may appear lower due to a dilution effect because of a rapid accumulation of biomass and larger total biomass production as compared to temperate hybrids. In 1991, approximately 75 kg N ha^{-1} was needed to reach the sufficiency level of 2.5 g kg^{-1}, whereas in 1992, approximately 50 kg N ha^{-1} was needed for the starter treatments without N. A significant interaction between tillage and N rate in 1991 occurred in that the strip tillage system resulted in slightly higher P concentrations at

Table 1
Rainfall (mm) by month at the Wiregrass Substation, Headland, AL, for 1990, 1991, and 1992

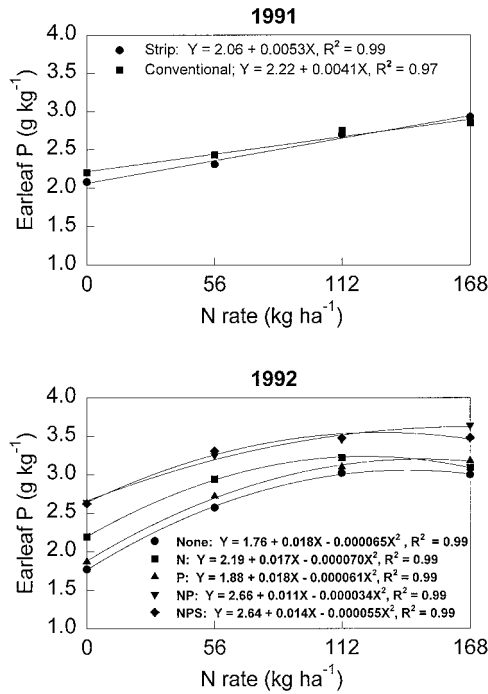| Month	1990	1991	1992	30-yr average
May	88.1	223.3	25.2	88.9
June	69.6	34.3	88.6	109.2
July	80.8	146.8	232.9	127.0
August	30.0	141.2	133.9	132.1
September	19.6	68.8	18.5	119.4
Total	288.1	614.4	499.1	576.6

Fig. 1. Phosphorus concentrations in tropical maize ear leaves collected at early silk as affected by tillage system and N rate in 1991, and by starter fertilizer treatments and N rate in 1992. For 1992: None = no starter; N = 22.4 kg N ha^{-1}; P = 22.4 kg P ha^{-1}; S = 11.2 kg S ha^{-1}.

lower N rates whereas the two tillage systems were essentially the same at the higher N rates. In 1992, there was a significant interaction between N rate and starter treatments (Fig. 1). The addition of P to the starter increased ear leaf P relative to the no starter treatment, however, the highest P concentrations resulted when the starter included a combination of both P and N.
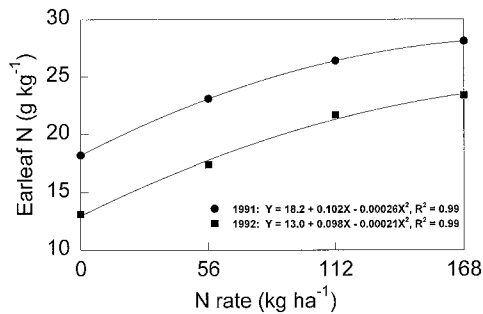

Fig. 2. Nitrogen concentrations in tropical maize ear leaves collected at early silk as affected by the rate of N fertilizer (averaged over starter and tillage treatments) in 1991 and 1992.

Table 2
Nitrogen concentrations (g kg^{-1}) in earleaves sampled at early silk as affected by starter fertilizer (averaged over N rates and tillage systems)

Starter treatment[a]	1991	1992
None	23.8	17.5
N	24.7	18.2
P	23.4	18.9
NP	23.7	20.0
NPS	24.3	19.9
LSD$_{0.05}$	0.1	0.1

[a] N = 22.4 kg N ha^{-1}; P = 22.4 kg P ha^{-1}; S = 11.2 kg S ha^{-1}.

In 1991 and 1992, ear leaf N concentrations increased with increasing rates of N regardless of starter or tillage treatment (Fig. 2). In 1991, N rates over 120 kg ha^{-1} were needed to obtain the N sufficiency range reported for temperate maize (27.5–35.0 g kg^{-1}; Plank, 1989). Sufficiency ranges for adequate growth of temperate maize may not be the same as for tropical maize. Because tropical maize accumulates biomass at a faster rate as compared to temperate maize, N levels may be more diluted in tropical hybrids. Nitrogen in the maize ear leaves was also affected by starter treatments (Table 2). A comparison of 1991 and 1992 data show that the response to the starter was not consistent for the 2 yr. In 1991, N and NPS starter gave higher concentrations of N relative to the no starter (None) check treatment, whereas all starter treatments resulted in higher ear leaf N concentrations relative to the no starter check in 1992 (Table 2). In 1992, the NP starter resulted in the highest ear leaf concentration of N.

3.2. Silage yields

Silage yields were determined each year of the test and there were no interactions between tillage, and starter fertilizer treatments. Excellent silage yields were obtained, especially in 1990 (Table 3). During 1990 and 1991, the strip tillage system produced significantly more silage than conventional tillage (average difference = 14%). In 1990,

Table 3
Tropical corn silage yields (35% dry matter, Mg ha^{-1}) averaged over N rates as affected by starter fertilizer treatment and tillage system in 1991

Starter fertilizer[a]	1990[b]	1991		1992[b]
		Conventional	Strip	
None	37.9	21.3	21.7	15.1
N	41.9	19.9	24.6	20.1
P	38.8	22.0	22.4	17.3
NP	44.8	23.7	25.3	21.3
NPS	46.1	20.6	24.0	20.5
LSD$_{0.05}$	4.7	2.24[c]		1.9

[a] N = 22.4 kg N ha^{-1}; P = 22.4 kg P ha^{-1}; S = 11.2 kg S ha^{-1}.
[b] Averaged over tillage treatments.
[c] Interaction LSD for the comparison of two starter means at the same or different tillage system.

the conventional and strip tillage systems averaged 38.3 and 45.5 Mg ha^{-1}, respectively. Silage yields of temperate maize in Alabama average approximately 22.4 Mg ha^{-1}. In 1991, the variety was changed from Pioneer X304C to Pioneer 3072. Hybrid Pioneer 3072 had been shown to be a high yielding tropical variety for grain (Reeves, 1992) whereas X304C is a high silage/low grain yielding hybrid (Reeves, 1992; Teare et al., 1991b). Thus, a change in hybrid was made since we were interested in tropical maize as an alternative source of both grain and silage. Due to hybrid differences, silage yields were lower in 1991 than 1990 (Table 3). Silage yields in 1991 averaged 21.5 and 23.7 Mg ha^{-1} in conventional and strip tillage systems, respectively. Silage yields were lower in 1992 than 1991 and except for a significant N rate by tillage interaction ($P \leq 0.05$; Fig. 3), there were no differences between tillage systems. Lower yields in 1992 as compared to 1991 were attributed to poorer rainfall distribution (Table 1) and a slightly later planting date (9 days) in 1992 as compared to 1991. Lilly et al. (1993) showed that tropical corn yields decrease with later planting dates. Lower yields were attributed (Lilly et al., 1993) to high summer temperatures, high humidity and the occurrence of southern corn rust [*Puccinia polysora* (Undrew)] and fall armyworm.
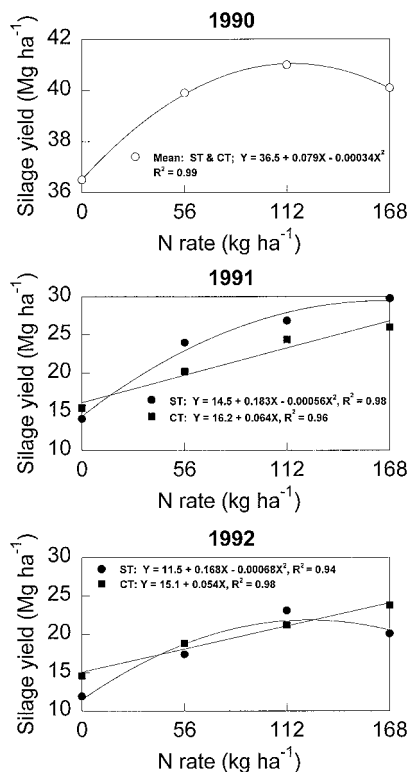

Fig. 3. Tropical maize silage yields as affected by N rate and tillage system (ST = strip tillage; CT = conventional tillage). In 1991 and 1992, there was a significant interaction ($P \leq 0.05$) between tillage system and N rate.

In 1991 and 1992, there was a linear response to N rate under conventional tillage (Fig. 3). In 1991, higher yields and an overall better response to N was obtained under the strip tillage system. In 1990, the interaction between tillage and N rate ($P = 0.08$) was most likely due to the variety grown in 1990 (Pioneer X304C) as well as drought conditions (Table 1) and severe infestation of fall armyworm. The Pioneer X304C hybrid still produced excellent silage yields in spite of the stress imposed by insects and drought. Trends in the yield data for the tillage treatments and across N rates in 1990 were similar to the results observed in 1991. Silage yields in 1991 and 1992 suggest that higher rates of N would be required under conventional tillage as compared to strip tillage on this soil. Higher silage and grain yield under strip tillage, especially in 1991, may reflect a conservation of soil moisture resulting from less soil disturbance (soil moisture data were not collected). Bauer and Busscher (1993) measured soil moisture on a Norfolk loamy sand (Typic Kandiudults) in South Carolina (USA) where cotton (*Gossypium hirsutum* L.) was produced following rye (*Secale cereal* L.) using conventional (incorporation of residues followed by in-row subsoiling) and strip tillage (in-row subsoiling) systems. Soil moisture content was higher under strip tillage as compared to conventional tillage. The tillage systems used by Bauer and Busscher (1993) were similar to those used in this study. Other field (Gallaher, 1977; Jones et al., 1969; Lal, 1986; Reeves et al., 1992) and greenhouse (Hubbard and Jordan, 1996) studies have also demonstrated that reduced tillage and surface mulch can result in a conservation of soil moisture.

The best starter treatment for silage production was the NP treatment (Table 3). In 1990 and 1992, there were no interactions between tillage, N rates and starter treatments. The NP starter increased silage yields (relative to the no starter check) by 6.9 and 6.2 Mg ha^{-1} in 1990 and 1992, respectively. However, in 1992, the numerical difference between the NP and N alone starter treatments was not significant. In 1991, there was a significant interaction between tillage and starter treatments. During 1991, the best response to starter was under the strip tillage system where the N, NP and NPS starter treatments produced significantly more silage than the no starter check treatment.

3.3. Grain yields

Grain yields were determined only in 1991 and 1992. In 1990, fall armyworm infestations were so severe that grain yields were not determined. Grain yields in 1992 were lower as compared to 1991 (Fig. 4). Lower yields in 1992 were attributed to poor rainfall distribution (Table 1) and planting 9 days later in 1992 as compared to 1991. Grain yields were affected by the interaction between tillage and N rate in both 1991 and 1992, with higher yields at all N rates occurring under strip tillage in 1991. In 1992, there were no differences between the two tillage systems at rates of 56 and 112 kg N ha^{-1}.

For grain, N alone as a starter under the conventional tillage system was adequate in 1991 (Table 4). A significant interaction between starter treatments and tillage system occurred in that there were no significant differences among starter treatments under the strip tillage system in 1991. In 1992, the best starter for grain production was the NP treatment.

1991

Grain yield (Mg ha^{-1})

ST: $Y = 1.87 + 0.041X - 0.00013X^2$, $R^2 = 0.99$
CT: $Y = 1.64 + 0.026X - 0.000081X^2$, $R^2 = 0.99$

N rate (kg ha^{-1})

1992

Grain yield (Mg ha^{-1})

ST: $Y = 1.39 + 0.021X - 0.000085X^2$, $R^2 = 0.95$
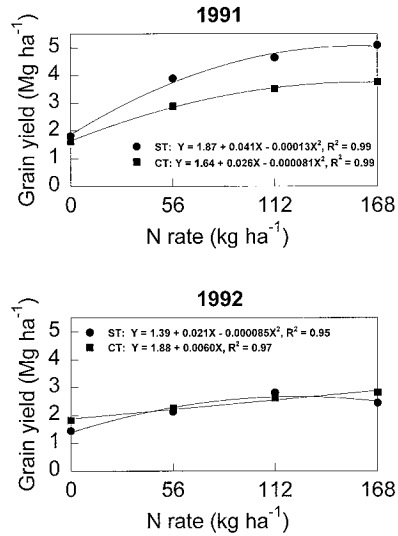CT: $Y = 1.88 + 0.0060X$, $R^2 = 0.97$

N rate (kg ha^{-1})

Fig. 4. Tropical maize grain yields in 1991 and 1992 as affected by tillage system and N rate. ST = strip tillage; CT = conventional tillage.

Grain yields were 3.4 Mg ha^{-1} in 1991 and 2.2 Mg ha^{-1} in 1992 when averaged over all treatments. Teare et al. (1991b) obtained a similar yield of 2.4 Mg ha^{-1} in 1990 for Pioneer hybrid 3072 in a non-irrigated, strip tillage system with a similar planting date in Florida. The yields obtained in this study also compete well with summer planted non-irrigated temperate maize which averages 1.8 Mg ha^{-1} in the Southeastern USA (Teare and Wright, 1990). All of the grain yields mentioned above would not compete economically with expected grain yields of spring planted temperate maize hybrids. However, silage yields of double cropped tropical maize hybrids would be economically competitive.

Table 4
Tropical corn grain yields (Mg ha^{-1}) averaged over N rates as affected by starter fertilizer treatments and by conventional and strip tillage in 1991

Starter fertilizer[a]	1991		1992[b]
	Conventional	Strip	
None	2.4	3.7	1.8
N	4.0	3.9	2.4
P	2.4	3.6	2.1
NP	3.6	4.1	2.6
NPS	2.4	4.0	2.5
LSD$_{0.05}$	0.7[c]		0.2

[a] N = 22.4 kg N ha^{-1}; P = 22.4 kg P ha^{-1}; S = 11.2 kg S ha^{-1}.
[b] Averaged over tillage treatments.
[c] Interaction LSD for the comparison of two starter means at the same or different tillage system.

3.4. Silage quality

Forage quality parameters commonly reported to farmers include crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF). The optimum range in temperate maize silage (National Council of Research, 1988) is considered to be 81–84, 510–530, and 280–300 g kg^{-1} for CP, NDF and ADF, respectively. Forage quality of the harvested silage in 1991 and 1992 (hybrid Pioneer 3072) was affected primarily by N rate (Fig. 5). Crude protein, NDF and ADF were not affected by tillage, the application of starter fertilizer or by any interaction among main effects. As expected, crude protein increased with increasing N rate. Both acid detergent fiber (ADF) and neutral detergent fiber (NDF) decreased with increasing N rate which would be desirable from the standpoint of dry matter intake and digestibility by the consuming animals (van Soest, 1982). Average values of CP, NDF and ADF, generally fell just outside of the accepted optimum range for temperate maize silage. Crude protein values were low compared to optimum values, while NDF and ADF were slightly high compared to optimum values. However, when compared to typical silage quality values for temperate maize growing in the southeastern US, tropical maize hybrid Pioneer 3072 produced
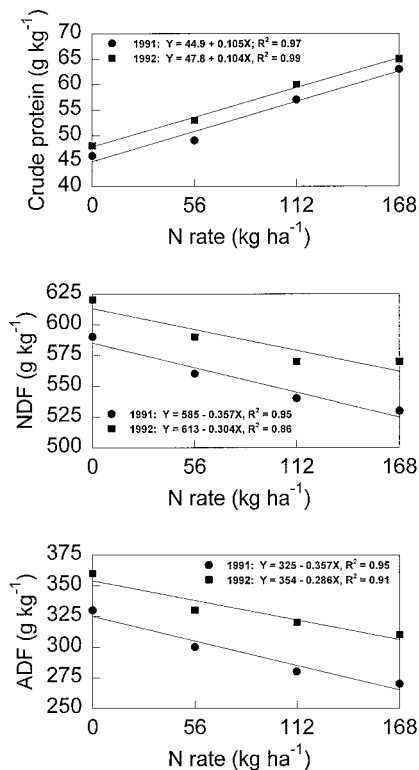
Fig. 5. Crude protein, neutral detergent fiber (NDF) and acid detergent fiber (ADF) in tropical maize silage in 1991 and 1992 as affected by N rate.

silage of similar quality to that of temperate maize (Pete Moss, Professor of Dairy Science, Auburn University, personal communication). Monson et al. (1980) compared silage quality of a short season dent maize cultivar with hybrid Pioneer X304C in Georgia (USA). They reported that the tropical maize hybrid produced forage of quality equal to the short season dent cultivar.

4. Summary

In 2 out of 3 yr, higher silage yields were obtained under a strip tillage system as compared to conventional tillage. Grain yields were higher under strip tillage in 1 out of 2 yr. Higher yields under strip tillage may reflect a greater conservation of soil moisture. In the strip tillage system, there was less soil disturbance and the wheat residue on the surface served as a mulch. Tropical maize hybrid Pioneer X304C produced high silage yields with lower amounts of N as compared to the hybrid with higher grain yield potential (Pioneer 3072). Nitrogen response was greater for this hybrid under conventional tillage than strip tillage. Forage quality of silage was not affected by tillage system or starter, but increased with increasing rates of N. The quality parameters measured (CP, NDF and ADF) were comparable to temperate maize silage produced in the southeastern USA.

In 2 out of 3 yr, silage yields were increased with the use of NP (22.4 kg N and 22.4 kg P ha^{-1}) starter fertilizer. In the 3rd yr of the test, N alone as a starter was acceptable although the NP starter treatment gave slightly higher yields. The lack of a definite improvement in yields by the NP starter over the N alone starter may have been due to a lower yield potential in the 3rd yr due to a slightly later planting date as compared to the first 2 yr. For grain, the N alone starter treatment under conventional tillage produced the highest yields in 1991, while the NP starter treatment produced the highest yields in 1992. These responses to starter fertilizer are similar to responses observed for early-spring planted temperate maize in the southern USA (Reeves et al., 1986; Touchton and Karim, 1986; Touchton, 1988; Wright, 1989)

Results from this study were generated using one experimental site and one soil type, but they should be applicable to other temperate/subtropical regions where tropical maize hybrids are grown on sandy soils.

5. Conclusion

This study has demonstrated that double cropped tropical maize is a promising alternative crop for the southeastern USA. High silage yields and reasonable grain yields can be obtained using conservation tillage systems and the addition of N in combination with a starter fertilizer containing N and P. Previous work has shown that there is a lot of genetic variability in grain yield potential for tropical maize hybrids. Additional work to develop or select high yielding grain varieties could make it economically possible to grow double-cropped tropical maize for grain in southern temperate/subtropical regions.

The results of this study demonstrate that the key component of starter fertilizer for tropical maize is N. Our results also suggest that for optimum tropical maize yields when planted from late spring–early summer, a starter fertilizer with N and P would be recommended for temperate/subtropical regions

Acknowledgements

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